Navigating Bowel Preparation for Colonoscopy
A Comprehensive Overview

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Abstract: Colorectal cancer (CRC) is the third most common cancer in the United States. Early detection through colonoscopy significantly improves survival rates. Detecting colon polyps depends on the quality of bowel preparation. However, inadequate bowel preparation remains a significant issue in clinical practice. Efforts to address this challenge have led to the development of bowel preparation regimens emphasizing efficacy, tolerability, and safety. Bowel preparation options can be categorized by their osmotic and volume properties. Isosmotic solutions based on polyethylene glycol-electrolyte lavage solutions (PEG-ELS) are available in both low-volume PEG-ELS with ascorbic acid (PEG-Asc) (e.g., MoviPrep, PLENVU) and high-volume formulations (e.g., GoLYTELY, CoLyte), as well as sulfate-free high-volume PEG-ELS formulations (SF-PEG-ELS). Hyperosmotic solutions include oral sulfate solution (OSS) (e.g., SUPREP), sodium phosphate tablets (NaP) (e.g., OsmoPrep), oral sulfate tablets (OST) (e.g., SUTAB), flavored PEG with sulfate salts (FPSS) (e.g., SUFLAVE), and magnesium citrate. Hypoosmotic solutions consist of PEG-sports drink (PEG-SD). In addition, combination solutions are available, such as sodium picosulfate with magnesium citrate (SPMC) with laxatives (e.g., CLENPIQ), and OSS with SF-PEG-ELS (Suclear). Each regimen differs in terms of cost, volume, taste, contraindications, and potential adverse effects. Therefore, clinicians must carefully evaluate each patient to determine the most suitable regimen for their patients.

Key Words: bowel preparation, colonoscopy, colon cancer screening, laxatives, magnesium citrate, polyethylene glycol

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Colorectal cancer (CRC) is the third most common cancer and the second leading cause of cancer-related deaths in the United States (US).[1] Colonoscopies reduce CRC incidence and mortality by enabling endoscopists to detect and remove potentially precancerous polyps.[2] Adequate bowel preparation facilitates clear visualization of the colonic mucosa and can improve this effort.[3,4] Conversely, insufficient preparation reduces the detection of polyps, hindering their detection and removal.[5] Furthermore, suboptimal preparation can result in unnecessary procedures,[1] shorter surveillance intervals,[6] longer procedure times,[7] reduced cecal intubation rates, increased use of electrocautery, and a greater likelihood of complications.[8,9]

Suboptimal bowel preparation is reported in 20% to 25% of colonoscopies and is the main cause of incomplete examinations.[10] Froehlich et al[11] observed improved odds ratios (OR) of 1.46 and 1.73 for polyp detection when comparing fair bowel preparations with high or intermediate-quality bowel preparations, respectively. Similarly, Holt et al[12] found a correlation between preparation quality and adenoma detection rates, showing that low-quality bowel preparation reduces polyp detection (OR: 0.39). Inadequate bowel preparation increases the need for more frequent colonoscopies and follow-up intervals, impacting patient safety and raising screening costs by 12 to 22%.[9] The US Multi-Society Task Force on Colorectal Cancer recommends repeating the colonoscopy within one year for those with inadequate bowel preparation.

Recognizing the significance of bowel preparation highlights the need for a standardized scoring system. Scores such as the Ottawa Bowel Preparation Scale (OBPS) (Table 1) and Boston Bowel Preparation Scale (BBPS) (Table 2) help to ensure precise evaluation and reporting. There is a growing initiative to monitor bowel preparation adequacy, focusing on both individual endoscopists and entire endoscopy units. These efforts aim to identify improvements in bowel preparation selection and patient instructions. Bowel preparation adequacy, like cecal intubation and adenoma detection rates, is increasingly recognized as an important metric to track.

The long-established standard bowel preparation regimen involves consuming 4-L of fluid containing polyethylene glycol (PEG) 3350; however, due to its substantial volume and unpalatable taste, it can be poorly tolerated. Some of the burden associated with large volumes has been reduced with the adoption of the split-dose method. Instead of taking the entire volume the night before the examination, patients now ingest half of the bowel preparation the evening before the colonoscopy and the rest within 4 to 8 hours before the procedure. Split-dose timing for bowel preparation is the gold standard due to its demonstrated benefits, including improved bowel preparation quality, enhanced adenoma detection rate,[13] and superior tolerability.[14,15]

Despite split dosing of bowel preparations, patients still generally find bowel preparation unpleasant. Surveys consistently show it is the most challenging part of undergoing a colonoscopy. Consequently, those who struggle with it are often reluctant to undergo another colonoscopy.[16] Several formulations aimed at simpler and better-tolerated alternatives have emerged to address this, each with

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J.B. conceptualized the review and provided extensive edits. R.H. conducted the literature search, drafted the manuscript, and created the tables. M.N. and J.A. provided extensive edits and commentary.

The authors declare that they have nothing to disclose.

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TABLE 1. The Ottawa Bowel Preparation Scoring (OBPS) System Assigns Scores Ranging From 0 (Excellent) to 4 (Inadequate) for Each Colonic Segment (Right Colon, Mid-colon, and Rectosigmoid Colon)

Preparation quality per colonic segment	Score
Excellent: Mucosal detail clearly visible, almost no stool residue; if fluid is present, it is clear, almost no stool residue	0
Good: Some turbid fluid or stool residue, but mucosal detail still visible without need for washing/suctioning	1
Fair: Some turbid fluid or stool residue obscuring mucosal detail; however, mucosal detail becomes visible with suctioning, washing not needed	2
Poor: Stool present obscuring mucosal detail and contour; a reasonable view is obtained with suctioning and washing	3
Inadequate: Solid stool obscuring mucosal detail and not cleared with washing and suctioning	4
Quantity of fluid throughout colon	Score
Small amount of fluid	0
Moderate amount of fluid	1
Large amount of fluid	2

The total quantity of fluid throughout the colon receives a score of 0 (small volume) to 2 (large volume). These scores are totaled, resulting in an overall score of 0 (excellent) to 14 (inadequate). There is no specific threshold provided for inadequate preparation.

distinctions regarding taste, volume, cost, efficacy, and potential side effects. The volume of the solution remains a key factor. Most new bowel preparations focus on creating low-volume, easy-to-consume options that remain effective. Our objective is to examine available bowel preparation options, enabling clinicians to make informed decisions when discussing them with their patients.

BOWEL PREPARATION REGIMENS

The primary goal of bowel preparation is to clear the colon of residue while preserving the patient's physiological state.[17] When determining the optimal bowel preparation regimen, one must consider the efficacy, cost, taste, volume, and side effects. This is particularly important for vulnerable populations, such as elderly patients and those with chronic kidney, hepatic, or cardiac comorbidities. Various regimens are available, categorized by osmolarity and mechanism of action (Tables 3 and 4). In this review, we will examine the differences among the isosmotic, hyperosmotic, hypoosmotic, and combination bowel preparation solutions, along with formulations containing stimulant laxatives.

ISOSMOTIC SOLUTIONS

Isosmotic solutions function by introducing a non-absorbable osmotic agent into the colon, delivering a non-absorbable liquid volume that minimizes fluid exchange and results in liquid stool.[17] The most commonly used isosmotic bowel preparation solutions are different formulations of PEG 3350-electrolyte lavage solution (PEG-ELS), available in high-volume PEG (4-L) and low-volume (2-L or 1-L) options. PEG 3350, a non-absorbable polymer, maintains osmotic balance and is non-fermentable. This property allows it to pass through the colon without causing net absorption or secretion, mitigating fluid and electrolyte shifts.[10] Other ingredients include anhydrous sodium sulfate, sodium bicarbonate, sodium chloride, and potassium chloride.

PEG-ELS

PEG-ELS is a 4-L solution branded as Nulytely, GoLYTELY, or CoLyte, priced at ~28.19 US dollars (USD), 26.34 Euros (EUR) or 59.20 Canadian dollars (CAD). Consuming the entire 4-L of PEG can be challenging for many patients due to its large volume, with reports that 5% to 15% of patients do not finish it.[18,19] Despite this challenge, 4-L of PEG-ELS remains the gold standard for bowel preparation and serves as the benchmark against which other methods are compared. A meta-analysis showed a pooled OR of 3.46 for achieving a BBPS of good (i.e., BBPS 6 or 7) or excellent (i.e., BBPS 8 or 9) bowel preparation, both of which indicate adequate preparation with 4-L of PEG-ELS compared with older alternative regimens. Interestingly, one study found no significant differences between PEG and alternative methods regarding preparation compliance, overall positive experience, and willingness to repeat the same bowel preparation.[20]

PEG-ELS offers a favorable safety profile due to its balanced osmolarity and therefore generally considered safe.[21] Common adverse effects are primarily gastrointestinal (GI), such as nausea, vomiting, and bloating.[22] Rare side effects include hypersensitivity or allergic reactions and anaphylaxis.[21,23] Serious risks, though uncommon, can result from electrolyte imbalances, potentially leading to cardiac arrhythmias, seizures, or tremors. Many of the side effects and serious complications associated with PEG-ELS

TABLE 2. The Boston Bowel Preparation Scoring (BBPS) System Assigns Scores Ranging From 0 (Very Poor) to 3 (Excellent) to Each Colonic Segment (Right Colon, Transverse Colon, and Left Colon) After Washing or Suctioning

Preparation quality per colonic segment	Score
Inadequate: The colon is unprepared, with solid stool obscuring the view of the mucosa.	0
Poor: Portions of the colonic mucosa are visible, but other areas remain obscured because of staining, residual stool, and/or cloudy liquid.	1
Good: The majority of the colonic mucosa is well visualized, with minimal staining, small amounts of residual stool, and/or cloudy liquid.	2
Excellent: The entire colonic mucosa is clearly visualized, with no residual staining, stool, or cloudy liquid.	3

These scores are totaled to give an overall score ranging from 0 (very poor) to 9 (excellent). Adequate bowel preparation is defined as achieving a total score of ≥ 6 and any segment score less than < 2 is considered inadequate.

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TABLE 3. Summary of Available Bowel Preparations Organized by Mechanism of Action, Ingredients, Advantages, Disadvantages, and Contraindications

	PEG-ELS	SF-PEG-ELS	PEG-Asc		OSS	NaP	OST	FPSS	Magensium Citrate	SPMC	PEG-SD
Brand name	**GoLYTELY, CoLyte**	**NuLYTELY, TriLyte**	**MoviPrep**	**PLENVU**	**SUPREP, Suclear**	**OsmoPrep**	**SUTAB**	**SUFLAVE**	**Magnesium Citrate**	**CLENPIQ**	**MiraLAX**
Generic availability	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes
Osmotic properties	Isosmotic	Isosmotic	Isosmotic	Isosmotic	Hyperosmotic	Hyperosmotic	Hyperosmotic	Hyperosmotic	Hyperosmotic	Combination	Hyposmotic
Mechanism of action	Osmotic effect of PEG 3350 causes water to be retained in the colon.	Osmotic effect of PEG 3350 causes water to be retained in the colon.	Osmotic effect of PEG 3350 causes water to be retained in the colon.		Osmotic effect of unabsorbed sulfate anions causes water to be retained in the colon.	Osmotic effect of sodium causes water to be retained in the colon.	Osmotic effect of sodium sulfate and magnesium sulfate causes water to be retained in the colon.	Osmotic effect of PEG 3350, sodium sulfate, and magnesium sulfate cause water to be retained in the colon.	Osmotic effect of magnesium citrate causes water to be retained in the colon.	Osmotic effect of sodium picosulfate, magnesium sulfate, and citric acid cause water to be retained in the colon.	Osmotic effect of PEG 3350 causes water to be retained in the colon.
Ingredients	PEG 3350, sodium sulfate, sodium bicarbonate, sodium chloride, and potassium chloride.	PEG 3350, sodium chloride, sodium bicarbonate, and potassium chloride.	PEG 3350, sodium sulfate, sodium chloride, potassium chloride, sodium ascorbate, ascorbic acid, aspartame, acesulfame potassium, and lemon flavoring.	PEG 3350, sodium ascorbate, sodium sulfate, ascorbic acid, sodium chloride, and potassium chloride.	Sodium sulfate, potassium sulfate, magnesium sulfate, sodium benzoate, sucralose, malic acid, and citric acid.	Sodium phosphate monobasic monohydrate, and sodium phosphate dibasic anhydrous.	Sodium sulfate, magnesium sulfate, and potassium chloride	PEG 3350, sodium sulfate, potassium chloride, magnesium sulfate, sodium chloride, and lemon-lime flavoring.	Magnesium citrate.	Sodium picosulfate, magnesium sulfate, and anhydric citric acid.	PEG 3350 consumed with a sports drink (e.g., Gatorade).
Advantages	Safest option overall for patients with renal impairment; minimal risks, affordable.	More tolerable and palatable than PEG-ELS, with similar safety and cleansing efficacy.	Minimal electrolyte imbalances, comparable effectiveness to 4-L PEG-ELS with higher patient satisfaction.		Small volume, well-tolerated.	Oral tablets easier to consume and well-tolerated.	Easy to consume, well-tolerated, patients willing to repeat same bowel preparation.	Well-tolerated, good flavor, patients willing to repeat same bowel preparation.	Affordable option that reduces quantity of PEG-ELS required when used in combination.	Equivocal bowel cleansing, fewer adverse effects, improved palatability compared with 4L PEG-ELS.	Easily available, affordable, well-tolerated, non-inferior to PEG-ELS.
Disadvantages	Large volume, least tolerable, least palatable; patients less likely to repeat same bowel preparation compared with other regimens.	Large volume, less tolerable.	Use caution in patients with glucose-6-phosphate dehydrogenase deficiency due to risk of hemolysis.		Caution needed in patients with renal, heart, or liver failure.	Use caution in patients with heart or liver disease, and those on ACEi or ARB; costly.	Limited data on adverse effects due to new market presence; caution advised in renal failure or heart conditions; expensive.	New on the market with limited data on adverse effects; caution in renal failure or heart conditions.	Rare risk of magnesium toxicity in renal impairment; adjunct to other bowel preparations like stimulant laxatives.	Risk of electrolyte abnormalities, especially hypermagnesemia; caution in renal, heart, or liver failure; relatively expensive.	Decreased efficacy compared with 2-L PEG-ELS; not FDA-approved; may cause unclear electrolyte shifts.
Contraindications	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• Biopsy-proven acute phosphate nephropathy • GI obstruction • Bowel perforation • Gastric bypass or stapling surgery • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• None listed	• Severe renal impairment (CrCl < 30ml/min) • GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient	• GI obstruction • Bowel perforation • Gastric retention • Ileus • Toxic colitis or toxic megacolon • Known allergy or hypersensitivity to any ingredient

FDA indicates Food and Drug Administration; FPSS, flavored PEG and sulfate salts; GI, gastrointestinal; NaP, sodium phosphate; OSS, oral sodium sulfate; OST, oral sulfate tablets; PEG, polyethylene glycol; PEG-Asc, PEG-ELS with ascorbic acid; PEG-ELS, PEG 3350-electrolyte lavage solution; PEG-SD, PEG-sports drink; SF-PEF-ELS, Sulfate-free PEG-electrolyte lavage solutions; SPMC, sodium picosulfate with magnesium citrate.

are also present in other bowel preparations, as PEG-ELS is considered the safety standard for comparison against other regimens. It is important to review medications that may contribute to fluid or electrolyte disturbances and to address any imbalances before administering PEG-ELS.[22]

In patients with an elevated risk of electrolyte abnormalities, electrocardiograms and a basic metabolic panel should be considered before and after using PEG-ELS. A basic metabolic panel is useful for evaluating kidney function and electrolyte abnormalities in vulnerable populations, such as those with dehydration, renal dysfunction, cirrhosis, or those taking medications that affect renal function (e.g., diuretics, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, or non-steroidal-anti-inflammatory drugs). Exercise caution in patients with a recent myocardial infarction, unstable angina, heart failure, cardiomyopathy, a history of prolonged QT, or other uncontrolled arrhythmias. Generalized tonic-clonic seizures have been reported in rare cases of electrolyte dysfunction and low serum osmolality, but they often resolve with electrolyte and fluid repletion. Caution is advised in patients at increased risk of seizures, such as those with a history of seizures, individuals withdrawing from benzodiazepines or alcohol, those with suspected hyponatremia, or patients taking medications that lower the seizure threshold.

Mucosal ulcerations and ischemic colitis are rare side effects of osmotic laxatives, which necessitates caution in patients with inflammatory bowel disease (IBD). The risk increases when PEG-ELS is used alongside stimulant laxatives (e.g., sodium picosulfate or bisacodyl). Patients at risk of aspiration should be monitored during consumption. Elderly patients are often more susceptible to adverse effects due to decreased hepatic, renal, or cardiac function. Bowel preparations are contraindicated in patients with GI obstruction or perforation. Serious adverse reactions are limited to rare case reports involving patients over age 60 who developed a Mallory-Weiss tear, esophageal perforation, asystole, pulmonary edema, and pulmonary infiltrates secondary to aspiration.[22,24]

SF-PEG-ELS

Sulfate-free PEG-electrolyte lavage solutions (SF-PEG-ELS), such as NuLYTELY and its generic version TriLyte, were designed to improve the taste and odor of traditional PEG-ELS. This formulation costs ~23.30 USD (21.32 EUR or 44.82 CAD) for the standard 4-L volume. SF-PEG-ELS compromises PEG 3350, sodium bicarbonate, sodium chloride, and potassium chloride, often accompanied by flavor packs like lemon, lime, orange, or grapefruit. This enhancement was achieved by eliminating sodium sulfate, thereby reducing sodium entering the lumen, resulting in decreased potassium and increased chloride content.[25]

Patients prefer SF-PEG-ELS over PEG-ELS due to its superior taste (76.6% vs. 23.7%, $P < 0.0001$) while maintaining similar safety and cleansing efficacy.[6,26] Side effects of SF-PEG-ELS reflect those of other PEG-ELS-based products.[27] Subjects receiving SF-PEG-ELS were compared with patients who used PEG-ELS using mean ridit scores to assess differences between multiple variables. The mean ridit score estimates the probability that a randomly selected patient from one group will have a higher value than a randomly selected patient from the control group.[28] Patients receiving SF-PEG-ELS experienced less fullness (mean ridit score of 0.50 vs. 0.58) and fewer cramps (mean ridit score of 0.50 vs. 0.59) than PEG-ELS users. Paradoxically, PEG-ELS participants reported less nausea (mean ridit score of 0.43 vs. 0.50). Importantly, there were no discernible differences between the 2 groups regarding vomiting (mean ridit score of 0.46 vs. 0.50) or overall discomfort (mean ridit score 0.50 vs. 0.50). Moreover, SF-ELS-ELS and PEG-ELS demonstrated similar rates of adequate colonic cleansing (86.5% vs. 79.3%) and participants' willingness to undergo the procedure again.[26]

PEG-Asc

Low-volume PEG-ELS, which contain ascorbic acid (PEG-Asc), are branded as MoviPrep or PLENVU. These formulations were developed to improve taste and ease of use, featuring more manageable volumes of 2-L and 1-L, costing around 144.88 USD and 46.79 USD, respectively, or 132.54 EUR and 42.80 EUR. In Canada, the cost is ~78.47 CAD and 96.38 CAD. MoviPrep consists of PEG 3350, sodium sulfate, sodium chloride, potassium chloride, sodium ascorbate, ascorbic acid, aspartame, acesulfame potassium, and lemon flavoring. PLENVU contains PEG 3350, sodium ascorbate, sodium sulfate, ascorbic acid, sodium chloride, and potassium chloride.

Studies have demonstrated that PEG-Asc solutions provide patients a more positive experience while achieving similar bowel cleansing quality.[25] In a study comparing split-dose 4-L of PEG-ELS to 2-L of PEG with ascorbic acid, both exhibited similar cleansing capabilities ($P = 0.760$), whereas patients preferred the taste of PEG-Asc ($P < 0.001$).[26] In another study, MoviPrep demonstrated better tolerability than GoLYTELY (91.5% vs. 82.7%, $P = 0.02$).[29] Other studies have shown similar findings, with higher patient satisfaction scores for MoviPrep (85.2% vs. 52.4, $P < 0.001$) and fewer reported side effects.[30,31] A full dose of PLENVU contains 7.54 g of ascorbic acid.

The most common side effects of MoviPrep include malaise, nausea, abdominal pain, vomiting, dyspepsia, and anal discomfort. In contrast, PLENVU may cause nausea, vomiting, dehydration, abdominal pain, and a decline in glomerular filtration rate. Serious adverse reactions of PEG-Asc are similar to those of other PEG-based solutions mentioned above. PEG-Asc should be used cautiously in patients with glucose-6-phosphate dehydrogenase deficiency due to an increased risk of hemolysis from the sodium ascorbate and ascorbic acid it contains.[32] In addition, the phenylalanine contained in PEG-Asc is harmful to patients with phenylketonuria and should be used with caution in these individuals.[33,34]

HYPEROSMOTIC SOLUTIONS

Hyperosmotic solutions facilitate fluid movement into the bowel lumen, softening stool by increasing its water content and promoting colonic peristalsis.[35,36] These bowel preparations are typically avoided in patients at risk of significant intravascular volume shifts, such as those with congestive heart failure, end-stage renal disease, and cirrhosis. Solutions operating through this mechanism include oral sodium sulfate (OSS), NaP, OST, flavored PEG and sulfate salts (FPSS), and magnesium citrate.

OSS

Oral sodium sulfate (OSS), found in bowel preparation formulations like SUPREP and Suclear, does not cause

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significant electrolyte shifts because it contains sulfate and other poorly absorbed anions.[37] SUPREP consists of two 6-oz bottles of solution containing sodium sulfate, potassium sulfate, and magnesium sulfate as active ingredients, along with inactive ingredients including sodium benzoate, sucralose, malic acid, and citric acid. A SUPREP kit costs 61.80 USD, 56.54 EUR, or 174.88 CAD, whereas Suclear has been discontinued in the United States.

OSS has proven effective as a bowel cleanser, boasting a 94.7% success rate in one single-blind, randomized control trial (RCT)[38] and an impressive 95.4% success rate in another RCT.[39] Its overall effectiveness is comparable to that of PEG-Asc. Notably, split-dose OSS yielded a higher frequency of excellent preparation at 63.3%, compared with split-dose PEG-Asc, which achieved 52.5%.[37]

Di Palma and colleagues noted an increased rate of adequate bowel preparation with split-dose OSS (SUPREP) compared with single-dose 4-L of PEG-ELS, with 98.4% versus 89.6%, respectively ($P = 0.04$). Excellent bowel preparation was reported at 71.4% with OSS compared with only 34.4%, demonstrating OSS as a high-performing agent.[40] In addition, in elderly patients over 65, a comparison of split-dose OSS (Suclear) with PEG-ELS showed greater bowel preparation adequacy than PEG-ELS alone (93% vs. 86%).[41] Both regimens exhibited similar rates of adverse effects.

In a RCT comparing OSS to PEG-Asc in Japanese patients, the OSS group experienced significantly fewer adverse reactions than the PEG-Asc group ($P = 0.010$).[42] Common adverse effects of OSS include overall discomfort, abdominal distention, abdominal pain, nausea, fullness, vomiting, and electrolyte abnormalities (e.g., elevated total bilirubin, BUN, creatinine, osmolality, potassium, or uric acid). Less frequent adverse effects are similar to those of other PEG-based solutions. Given the safety and efficacy of OSS, its use for bowel preparation warrants further consideration. OSS is a promising agent, although its use is primarily limited by a relatively high cost.

NaP

NaP, available as OsmoPrep, is a prescription tablet with established efficacy, tolerability, and reduced volume.[16] Priced at 283.92 USD, 259.73 EUR, or 357.99 CAD for a pack of 32 tablets, OsmoPrep is relatively costly. Its active ingredients include sodium phosphate monobasic monohydrate and sodium phosphate dibasic anhydrous. NaP has demonstrated superior tolerability when compared with PEG-ELS. In a study involving 37 patients who had previously used PEG-ELS (GoLYTELY), subjects found NaP easier to complete, and 90% reported greater palatability.[43] Furthermore, NaP provided significantly better adequate colonic cleansing than GoLYTELY (80% vs. 33%, $P < 0.001$).

Other studies have consistently shown that NaP achieves bowel cleansing results equal to or better than PEG-ELS.[43,44] In a study comparing PEG-ELS to a NaP regimen, NaP yielded higher bowel cleansing scores, with a mean score of 4.01 compared with 3.88 for PEG-ELS, based on a scale ranging from poor (0) to very good (5) ($P < 0.001$). Moreover, this study demonstrated no significant differences in efficacy or safety between NaP and PEG-ELS in subjects without cardiac, renal, or hepatic failure. However, one study reported NaP use was associated with significantly more electrolyte imbalances, specifically hypokalemia and hyperphosphatemia ($P < 0.001$).[44] Bloating, nausea, abdominal pain, and vomiting are the most common side effects.[45]

Currently, the use of NaP is limited due to serious adverse effects, including renal failure, nephrocalcinosis, and renal tubular necrosis. NaP carries a black box warning for acute phosphate nephropathy, which can lead to renal failure.[46] In several cases, patients have developed renal impairment requiring long-term dialysis, with the onset of symptoms ranging from days to months after consuming NaP.[45] Markowitz and colleagues investigated 31 cases of nephrocalcinosis—a condition characterized by diffuse kidney injury resulting from tubular calcium phosphate deposits—in individuals who recently used NaP. Among these patients, 21 experienced acute renal failure, presenting with a mean creatinine level of 3.9 mg/dl, elevated from a mean baseline serum creatinine of 1.0 mg/dl. This elevation typically occurred at a median of one month after NaP consumption for colonoscopy preparation. The majority of individuals who developed acute phosphate nephropathy had a history of hypertension (73.2%), were taking angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, and had a mean age of 64 years.[47] Another limitation of NaP is its potential to damage the colonic mucosa, making it risky for patients suspected of having IBD.[48] If using NaP, patients should avoid additional sodium phosphate-based purgatives. Overall, the adverse side effect profile of NaP is greater than that of other bowel preparations.

OST

OST, marketed as SUTAB, contain sodium sulfate, magnesium sulfate, and potassium chloride, priced at ~170.55 USD, 156.02 EUR, or 235.07 CAD. This regimen involves consuming 24 tablets with 2.84-L (96-oz) of water in a split-dose manner. OSTs have shown efficacy in bowel cleansing comparable to PMC-based agents like CLENPIQ and low-volume PEG solutions such as MoviPrep.[10]

OST exhibited superior preparation quality and improved tolerability compared with low-volume PEG while maintaining similar rates of adverse effects (27.7% vs. 27.4%).[49] The overall side effect profile of OST is similar to other bowel preparations. In a single-blind, multicenter study comparing SUTAB to PEG-Asc, participants who received SUTAB experienced significantly less vomiting ($P < 0.001$) and nausea ($P < 0.001$). Moreover, SUTAB demonstrated a significantly higher rate of cleansing than PEG-Asc ($P = 0.034$). Subjects reported that SUTAB was significantly easy or very easy to consume ($P < 0.001$) compared with PEG-Asc and provided a significantly good or excellent overall experience ($P = 0.004$). Patients also reported a significantly better experience than their previous experiences ($P < 0.001$) and expressed a preference for using it again ($P = 0.005$). However, there is limited data available regarding the potential risks of using OST in individuals with electrolyte disturbances, heart conditions, or renal failure.[50] Therefore, further investigation into SUTAB use in these populations is warranted and should be carefully considered.

FPSS

FPSS, marketed as SUFLAVE, is a recently approved hyperosmotic, low-volume FPSS. It is available as a lemon-lime sports drink flavor to improve palatability. Introduced in August 2023, it is priced at 73.38 USD, 67.13 EUR, or 101.14 CAD and comprises PEG 3350, sodium sulfate,

TABLE 4. Summary of Available Bowel Preparations, their Costs, and Instructions

	Brand name	Volume of solution	Total volume consumed	Cost (USD); brand name, generic	Cost (EUR); brand name, generic	Cost (CAD); brand name, generic	Year of FDA approval	Instructions
PEG-ELS	GoLYTELY, CoLyte	4-L solution	4-L	$28.79*, $10.90*	€26.34, €9.97	$59.20†, $35.79†	1984	Add packet to 128-oz of water. Drink 8-oz every 10 minutes until 128-oz is consumed or rectal effluent is clear.
SF-PEG-ELS	NuLYTELY, TriLyte	4-L solution	4-L	$23.30*, $13.66*	€21.32, €12.50	$44.82†, N/A	1991	Pour flavor pack into a container and fill with 4-L water. Drink 8-oz every 10 minutes until 4-L are consumed or rectal effluent is clear.
PEG-Asc	MoviPrep	2-L solution	2-L	$144.88*, $46.79*	€132.54, €42.80	$78.47†, N/A	2006	Using the split-dose method: Consume 1-L of solution over 1 hour the day before the procedure, followed by 16-oz of clear fluid. On the morning of the procedure, consume another 1-L solution over 1 hour, then drink 0.5-L clear fluid.
	PLENVU		2-L	$51.34*, N/A	€46.97, N/A	$96.38†, N/A		Using the split-dose method: Pour contents into a container, add 16-oz water, and drink over 30 minutes. Repeat these steps the next morning.
OSS	SUPREP, Suclear	Two 6-oz of solution	12 oz/ 0.36-L	$61.80*, $27.34*	€56.54, €25.01	$174.88†	2010	Using the split-dose method: Pour one bottle of bowel preparation kit into a container, add 16-oz water, and consume. Then, consume 2 additional containers filled with 16-oz of water over 1 hour. Repeat these steps the next morning.
NaP	OsmoPrep	32 tablets (1.5-g total)	NA	$283.92*, N/A	€259.73, N/A	$357.99, N/A	2006; Black box warning in 2008 for nephropathy	Consume 4 tablets with 8-oz water every 15 minutes for a total of 20 tablets. The next morning, consume 4 tablets with 8-oz water every 15 minutes for a total of 12 tablets.
OST	SUTAB	Two bottles of 12 tablets each	NA	$170.55*, NA	€156.02, NA	$235.07, NA	2020	Using the split-dose method: Consume one bottle of 12 tablets, fill the container with 16-oz of water, and consume all tablets with water over 15-20 minutes. One hour later, consume another 16-oz water. 30 minutes later, consume another 16-oz of water over 30 minutes. Repeat these steps the next morning.
FPSS	SUFLAVE	Two 32-oz bottles	64-oz/1.9-L	$73.38*, NA	€67.13, NA	$101.14, NA	2023	Using the split-dose method: Pour a flavor-enhancing packet into one bottle, fill with water to fill line, and consume 8-oz every 15 minutes until the bottle is empty. Consume an additional 16-oz of water. Repeat these steps the next morning.
Magnesium citrate	Magnesium Citrate	Two 10-oz bottles	20-oz/ 0.59-L	$5.92	€5.42	$8.16	Not approved	Take 4 bisacodyl tables with an 8-oz glass of water. Five hours later, consume one bottle of magnesium citrate with an 8-oz glass of water. The next morning, consume the second bottle of magnesium citrate with an 8-oz glass of water.
SPMC	CLENPIQ®	Two 160-ml bottles	0.36-L	$90.16*, NA	€82.48	$124.27	2012	Consume 1 bottle of solution, followed by 40-oz of clear liquids within 5 hours. The next morning, consume the second bottle of solution followed by 32-oz of clear liquids.
PEG-SD	MiraLAX	238-g PEG 3350 in 1.9-L SD	1.9-L	12.93 USD‡ (for 30 packets of 17 g), N/A	€11.83	$17.82	Not approved	Mix the 238-g bottle of PEG 3350 with 64-oz of Gatorade, Powerade, or Crystal Light in a pitcher. Consume half of the mixture. The next morning, consume the second half of the mixture over 1 hour.

*Prices obtained from RxPriceQuotes.com April 2024, priced at Walgreens.
†Canadian prices obtained from CanadianPharmacyKing.com.
‡Prices obtained at GoodRx.com if price could not be found on RXPriceQuotes.com.
CAD indicates Canadian dollar; FDA, Food and Drug Administration; FPSS, flavored PEG and sulfate salts; NA, not applicable; NaP, sodium phosphate; OSS, oral sodium sulfate; OST, oral sulfate tablets; PEG, polyethylene glycol; PEG-Asc, PEG-ELS with ascorbic acid; PEG-ELS, PEG 3350-electrolyte lavage solution; PEG-SD, PEG-sports drink; SF-PEF-ELS, Sulfate-free PEG-electrolyte lavage solutions; SPMC, sodium picosulfate with magnesium citrate; USD, United States dollar.

potassium chloride, magnesium sulfate, and sodium chloride. These components are consumed in two 1-L bottles, along with a flavor-enhancing packet. Contraindications for taking FPSS follow those of OSS in general.

In a study conducted by Bhandari and colleagues, SUFLAVE demonstrated non-inferiority to OSS ($P < 0.001$) with comparable bowel cleansing efficacy (94% vs. 94%). Both preparations resulted in over 90% of segments with good or excellent preparation. Importantly, adenoma detection rates were similar between SUFLAVE and OSS, at 35% and 39%, respectively ($P = 0.261$). Preparation adequacy (99.1% vs. 96.9%, $P = 0.097$) and cecal intubation rate (99.1% vs. 98.2%, $P = 0.366$) were also comparable. Overall, patients expressed a preference for SUFLAVE. A significantly higher proportion of patients reported a more favorable experience with SUFLAVE, including a superior experience consuming FPSS ($P = 0.017$) and enhanced overall experience ($P = 0.016$). FPSS also had a significant advantage for preference in consuming it again ($P = 0.015$), superior overall taste ($P < 0.001$), and a better aftertaste ($P < 0.001$). There were no discernible differences in adverse effects between the 2 preparations, and no clinically relevant variations in laboratory parameters, such as electrolytes or vital signs, were observed. Adverse effects noted in both SUFLAVE and OSS groups included GI upset (13.7% vs. 13.7%), headache (1.8% vs. 1.8%), and urinary tract infection (0.4% vs. 1.3%).[51,52] The overall side effect profile of OSS is similar to other bowel preparations.

Magnesium Citrate

Magnesium citrate is an osmotically active agent that also stimulates cholecystokinin, leading to electrolyte and fluid shifts in the small intestine and colon. Although not approved by the Food and Drug Administration (FDA) for bowel preparation, it is often used as an adjunct to stimulant laxatives. Magnesium citrate is available over the counter for 3.99 USD per 296-ml bottle, or for 5.42 EUR and 8.16 CAD. Each 240-ml bottle contains 1.75 g of magnesium citrate. Magnesium citrate is often used with a stimulant laxative, such as bisacodyl (commercially known as Dulcolax), to create a dual-action approach. The stimulant increases peristalsis to promote bowel movement, whereas the osmotic laxative lavages.[53] In an assessor-blinded RCT evaluating the quality of colonic cleansing of a magnesium citrate capsule combined with bisacodyl, it achieved a 100% rate of colon cleanliness. Patients also reported higher satisfaction compared with those using 4-L of PEG-ELS (mean satisfaction score of 172.8 vs. 54.8; $P < 0.001$). Therefore, magnesium citrate may offer an affordable and effective option for colonoscopy preparation.[54]

However, magnesium citrate should be avoided in patients with significant renal disease due to the risk of magnesium toxicity, as it is primarily renally excreted. The signs and symptoms of magnesium toxicity, include bradycardia, hypotension, nausea, and drowsiness.[10] These effects are exceedingly rare, with minimal cases reported. For example, a case report described a 76-year-old woman who became lethargic, experienced a systolic blood pressure of 50 mmHg, and developed bradycardia and sinus arrest after receiving 34 g of magnesium citrate for ileus. She had no prior renal disease but presented with acute kidney injury with a creatinine of 1.4 mg/dl and a magnesium of 16.6 mg/dl.[55]

Most studies have reported only modest increases in serum magnesium concentrations after magnesium citrate intake. In a study investigating magnesium citrate administration in cases of toxic ingestions, the mean serum magnesium concentration rose by approximately 0.7 mEq/L after an average consumption of 960 ml of magnesium citrate, suggesting serum magnesium concentration does not correlate with the quantity of magnesium administered.[56] Advanced age is likely a risk factor for toxicity.

SPMC

CLENPIQ is a combination agent that includes the stimulant sodium picosulfate and the osmotic laxative magnesium citrate (SPMC), which draws water into the colon.[57] The solution consists of two 160-ml bottles priced at ~90.16 USD, 82.48 EUR, and 124.27 CAD. CLENPIQ received FDA approval in 2012. A randomized, investigator-blinded trial demonstrated that CLENPIQ was non-inferior to a solution of SPMC while showing superior overall colon cleansing. Subjects who received CLENPIQ reported successful colon cleansing rates of 87.7% compared with 81.5% for SPMC (95% CI 1.8%, 10.9%).[57] In a separate trial, an oral solution of SPMC also proved non-inferior to the comparator and achieved higher rates of successful colon cleansing (84% vs. 74%; 95% CI 3.4%, 16.2%).[57]

Some clinicians prefer SPMC for its improved tolerability compared with 4-L PEG-ELS, as it offers a better side effect profile while achieving comparable bowel cleansing.[57] SPMC carries a risk of electrolyte abnormalities; therefore, caution is needed in patients with significant renal, heart, or liver impairment. CLENPIQ poses a risk of hypermagnesemia and is therefore contraindicated in individuals with a creatinine clearance of < 30 ml/min. The most common adverse effects of SPMC are nausea, headache, hypermagnesemia, abdominal pain, dehydration, and dizziness. Elevated magnesium levels were observed in more subjects in the SPMC group than in the CLENPIQ group (5% vs. 2%), but these levels returned to baseline within 1 week.[57] As with other bowel preparations, fluid and electrolyte abnormalities pose a significant risk and can lead to serious complications such as seizures, arrhythmias, renal dysfunction, and syncope.

For high-risk patients, post-colonoscopy monitoring with basic metabolic panels and electrocardiograms should be considered. SPMC is safe in patients with mild or moderate baseline renal impairment or diabetes.[58] The most common side effects—nausea and headache—occurred in ~1.4% to 5.3% of patients.[58] Orthostatic changes in blood pressure and/or heart rate were reported in 20% of participants who consumed SPMC in both arms of clinical trials.[57] The few cases of syncope that have been reported typically occurred within 12 hours of consumption. Patients need to stay hydrated to mitigate this risk; however, hydration should be managed cautiously in individuals with heart failure.

HYPOOSMOTIC SOLUTIONS

The development of hypoosmotic bowel preparation solutions has been limited compared with isotonic and hyperosmotic solutions, which have been more extensively studied and proven effective. Consequently, few hypoosmotic formulations can achieve the same cleansing quality as hyperosmotic or isosmotic solutions. When taken alongside a commercially available electrolyte solution known as PEG-sports drink (PEG-SD), the combined solution forms a

hypoosmotic bowel preparation containing a low-volume 2-L PEG solution.[59]

PEG-SD is not FDA-approved for bowel preparation, primarily because it is not equivalent to 2-L of PEG-ELS formulations.[10] Moreover, PEG-SD has a minimal but statistically significant risk of electrolyte abnormalities.[59] Studies investigating the impact of PEG-SD on electrolyte shifts have been indeterminate. For example, McKenna and colleagues reported that 238 g of PEG taken with 1.9-L of Gatorade sports drink is safe, as it produced no statistically significant differences in electrolytes compared with PEG-ELS. PEG-SD was better tolerated than PEG-ELS, as evidenced by a higher overall experience rating (on a scale of 0 to 4) of 3.50 versus 3.00 ($P = 0.001$). In addition, patients expressed greater willingness to use PEG-SD in the future (93.8% vs. 72.5%; $P = 0.001$). Importantly, there were no differences in BBPS between the groups (7.4 ± 1.8 for PEG-SD vs. 7.4 ± 1.7 for PEG-ELS, $P = 0.98$), indicating that PEG-SD was non-inferior to PEG-ELS.[60]

2-L PEG-SD is frequently used for bowel preparation when combined with bisacodyl. However, studies comparing the efficacy of the 2-L PEG-SD plus bisacodyl regimen to the traditional 4-L PEG-ELS have yielded inconclusive results. Enestvedt et al[61] reported lower adenoma detection rates in subjects who received the 2-L of PEG-SD plus bisacodyl regimen (16.1%) due to inferior bowel preparation quality compared with those who consumed 4-L of PEG-ELS (26.2%).

Other studies have demonstrated clinically significant differences in bowel preparation quality between these 2 agents. A retrospective analysis found that subjects who received PEG-SD plus bisacodyl were more likely to achieve excellent or good bowel preparation relative to those who received PEG-ELS (93.3% vs. 89.3%, $P = 0.048$).[62] It's worth noting that the FDA-approved formulation of 2-L PEG-ELS plus bisacodyl, known as HalfLytely, was available from 2004 to 2010 but was discontinued due to safety concerns related to bisacodyl potentially causing ischemic colitis in this specific regimen.[63] However, PEG-SD remains a safe bowel preparation option alone with side effects similar to other bowel preparations. Notably, one study found increased rates of hyponatremia in patients using PEG-SD compared with PEG-ELS (3.9% vs. 2.2%), although the difference was not statistically significant.[59]

BOWEL PREPARATIONS FOR VULNERABLE POPULATIONS

Although various bowel preparations are available, there is no specific algorithm for selection in vulnerable patients. All purgatives carry a risk of electrolyte and fluid imbalances; however, hyperosmotic bowel preparations are more likely to cause fluid shifts that may not be tolerated in patients with chronic kidney disease, heart failure, and decompensated cirrhosis (Table 5).[64] In the elderly and those with renal, hepatic, or cardiac dysfunction, baseline and post-colonoscopy electrocardiograms and basic metabolic panels may be necessary to monitor for arrhythmias and assess BUN, creatinine, sodium potassium, and phosphorus levels. Patients should also be advised to maintain adequate hydration, targeting 2.5 to 3 L to replenish losses.[64]

ADJUNCT ADDITIONS TO STANDARD THERAPIES FOR BOWEL PREPARATIONS

Additional options for bowel preparation include the use of a stimulant laxative such as bisacodyl, senna, or magnesium citrate to complement marketed bowel preparations, aiming to improve colonic cleansing. This approach can be especially advantageous for patients with risk factors for inadequate preparation, such as those with a history of constipation, diabetes, or previous poor preparation despite following the prescribed regimen. In addition, adjunctive oral laxatives can sometimes enable patients to use a reduced volume of standard solution, which helps alleviate side effects like bloating.

Both bisacodyl and magnesium citrate have shown the ability to reduce the amount of PEG-ELS required for successful bowel preparation.[25,65,66] In one study, compared with a single-dose 4-L PEG-ELS regimen, the combination of 2-L of PEG-ELS with magnesium citrate yielded more effective bowel cleansing (51% vs.75%, $P = 0.001$) and similar bowel cleansing to split-dose 4-L PEG-ELS (76% vs. 75%, $P = 0.896$). Participants expressed greater willingness to repeat the bowel preparation regimen with 2-L of PEG-ELS plus magnesium citrate compared with split-dose PEG-ELS (93% vs. 62%, $P < 0.001$).[67]

Another study evaluated the efficacy and tolerability of 2-L of PEG-ELS combined with bisacodyl compared with 4-L of PEG-ELS, both administered as a split dose. The study found no significant difference in bowel cleansing effectiveness between the 2 methods. Patients preferred the regimen of 2-L of PEG-ELS combined with 15-mg of bisacodyl, reporting it was easier to consume (89.9% vs. 74.8%, $P < 0.001$), and they were more likely to repeat the procedure (98.7% vs. 73.6%, $P < 0.001$).[68]

Bisacodyl is a useful complement to other bowel preparations, augmenting bowel cleansing and sometimes allowing patients to consume less volume of solution. However, caution should be exercised due to the rare but increased risk of ischemic colitis. A study investigating the risk of segmental ischemia in patients taking four 5 mg bisacodyl tablets before a PEG-SD bowel preparation found that the incidence of ischemia was 7-fold higher in patients receiving bisacodyl (N = 9,018) compared with those who did not (N = 13,430) over 10 months (0.48% vs. 0.07%).[69]

The FDA restricted bisacodyl bowel preparations due to concerns about ischemic colitis, placing a black box warning on these preparations and withdrawing all formulations from the market in 2010.[70] However, due to the scarcity of cases bisacodyl preparations remain available in many countries.[70] By 2020, less than 35 cases of ischemic colitis resulting from bisacodyl had been published in the literature, with approximately 90% of ischemic colitis cases occurring in patients over the age of 60.[71]

Senna functions similarly to bisacodyl when used alongside PEG-ELS, enhancing tolerability while reducing the volume of solution consumed. In one study, senna was found to be equally effective as bisacodyl (98.3% vs. 95%) when taken in addition to GoLYTELY for bowel preparation.[72] In another investigation, subjects preferred 2-L of GoLYTELY plus senna to 4-L of GoLYTELY (73% vs. 1%). This method also resulted in adequate bowel preparation in 90% of the participants.[73] In another study comparing the efficacy of a 2-L of GoLYTELY combined with senna to a 4-L of GoLYTELY, both treatments demonstrated similar efficacy of colonic cleansing (71.9% vs.

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TABLE 5. Summary of Adverse Effects, With a Focus on Those in Vulnerable Populations

	Brand name	Common side effects	Rare side effects	Vulnerable populations
PEG-ELS	GoLYTELY, CoLyte	Nausea, abdominal fullness, bloating (present in up to 50% of patients), anal irritation, vomiting, and abdominal cramps.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, tremors, mucosal ulcerations, and aspiration. Very rare: Anaphylaxis, Mallory-Weiss tear, esophageal perforation, arrhythmia, atrial fibrillation, asystole, pulmonary edema, and pulmonary infiltrates secondary to aspiration.	Patients with cardiac arrhythmias, recent myocardial infarction, unstable angina, heart failure, cardiomyopathy, a history of prolonged QT, renal impairment, a history of seizures or those at risk of seizures, hyponatremia, concurrent use of medications that lower the seizure threshold, prolong QT, or affect renal function (e.g., diuretics, ACEi, ARBs, NSAIDs), inflammatory bowel disease, a history of aspiration, or older age.
SF-PEG-ELS	NuLYTELY, TriLyte	Nausea, abdominal fullness, bloating (present in up to 50% of patients), anal irritation, vomiting, and abdominal cramps.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, tremors, mucosal ulcerations, and aspiration. Very rare**:** Anaphylaxis, Mallory-Weiss tear, esophageal perforation, asystole, pulmonary edema, and pulmonary infiltrates secondary to aspiration.	Similar to PEG-ELS.
PEG-Asc	MoviPrep	Malaise, nausea, abdominal pain, vomiting, dyspepsia, and anal discomfort.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, tremors, mucosal ulcerations, and aspiration. Very rare**:** Anaphylaxis, Mallory-Weiss tear, esophageal perforation, asystole, pulmonary edema, and pulmonary infiltrates secondary to aspiration.	Caution in glucose-6-phosphate deficiency and phenylketonuria. Otherwise, similar to PEG-ELS.
	PLENVU	Nausea, vomiting, dehydration, abdominal pain, decline in GFR, electrolyte abnormalities, fatigue, and headache.		
OSS	SUPREP, Suclear	Overall discomfort, abdominal distention, abdominal pain, nausea, fullness, vomiting, and electrolyte abnormalities (e.g., elevated total bilirubin, BUN, creatinine, osmolality, potassium, and/or uric acid).	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, mucosal ulcerations, and aspiration.	Similar to PEG-ELS.
NaP	OsmoPrep	Bloating, nausea, abdominal pain, and vomiting.	Black box warning**:** Acute phosphate nephropathy Nephrocalcinosis, renal failure, renal tubular necrosis, electrolyte abnormalities, hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, mucosal ulcerations, and aspiration.	Contraindicated in patients with a history of acute phosphate nephropathy. Use caution in patients with severe renal impairment (CrCl $<$ 30ml/min), baseline kidney disease, hypovolemia, increased age, or those on medications that affect renal function (e.g. diuretics, ACEi, ARBs, NSAIDs). Otherwise, similar to PEG-ELS.
OST	SUTAB	Nausea, abdominal distention, vomiting, and upper abdominal pain.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, and mucosal ulcerations.	Similar to PEG-ELS.
FPSS	SUFLAVE	Nausea, abdominal distention, vomiting, abdominal pain, and headache.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, mucosal ulcerations.	Similar to PEG-ELS.

TABLE 5. (*continued*)

	Brand name	Common side effects	Rare side effects	Vulnerable populations
Magnesium citrate	Magnesium Citrate	Nausea, abdominal cramping, and diarrhea.	Hypermagnesemia, hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, mucosal ulcerations.	Avoid in patients with chronic kidney disease. Similar to PEG-ELS
SPMC	CLENPIQ	Nausea, headache, hypermagnesemia, abdominal pain, dehydration, dizziness, and orthostatic hypotension.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, mucosal ulcerations.	Similar to PEG-ELS.
PEG-SD	MiraLAX	Nausea, abdominal fullness, and bloating.	Hypersensitivity and allergic reactions, cardiac arrhythmias, seizures, renal injury, electrolyte abnormalities, mucosal ulcerations.	Similar to PEG-ELS.

ACEi indicates angiotensin-converting enzyme inhibitor; ARB, angiotension-receptor blocker; FPSS, flavored PEG and sulfate salts; NaP, sodium phosphate; OSS, oral sodium sulfate; NSAID, non-steroidal anti-inflammatory; OST, oral sulfate tablets; PEG, polyethylene glycol; PEG-Asc, PEG-ELS with ascorbic acid; PEG-ELS, PEG 3350-electrolyte lavage solution; PEG-SD, PEG-sports drink; SF-PEF-ELS, Sulfate-free PEG-electrolyte lavage solutions; SPMC, sodium picosulfate with magnesium citrate.

69.4%, $P = 0.58$). However, subjects who received 4-L GoLYTELY experienced significantly higher rates of adverse effects, nausea ($P < 0.001$), headache ($P = 0.002$), bloating ($P = 0.004$), and sleeplessness ($P = 0.021$).[74]

Linaclotide has also been studied as an adjunctive therapy for bowel preparation. A randomized control trial revealed that combining 2-L of PEG with 290-ug of linaclotide resulted in more effective bowel preparation compared with 2-L of PEG alone, and it was better tolerated than 4-L of PEG-ELS.[75] Therefore, future studies should examine the efficacy of linaclotide as a supplement to existing bowel preparation regimens.

METHODS TO IMPROVE PATIENT ADHERENCE

The quality of bowel preparation largely depends on the patient's adherence to colonoscopy preparation instructions, which can be particularly challenging for patients with low health literacy or non-native English speakers. To improve patient adherence, patients should receive both oral and written instructions, as this has been shown to enhance compliance and bowel preparation quality.[17] Standardized and validated educational aids, such as booklets, visual aids, videos, and smartphone applications, can further augment patient understanding. These resources should be tailored to different health literacy levels and made available in multiple languages.[76,77] In addition, both telephone ($P < 0.01$) and face-to-face instructions ($P < 0.001$) significantly improve bowel preparation quality.[78,79]

Patient navigators can also improve patient compliance by providing education and addressing barriers to colonoscopy. Studies have shown that navigators increase screening colonoscopy completion rates while remaining cost-effective.[80] For instance, a retrospective analysis indicated that navigators increased the likelihood of keeping a colonoscopy appointment by a relative risk of 2.6 (95% CI 2.2-3.0) and doubled the rate of screening colonoscopies from 57 per month to 119 per month.[80] Similarly, staff dedicated to patient education have been shown to improve bowel preparation quality ($P = 0.03$) and reduce cecal intubation time ($P < 0.01$).[81]

Several studies have identified the quantity of bowel preparation as the main factor deterring patients from repeating colonoscopy.[82] Split-dose bowel preparations improve patient adherence and satisfaction by allowing the same volume of bowel preparation to be taken over a longer period. Surveys indicate that most patients are willing to consume split-dose preparations.[14,83] A meta-analysis found that split-dose bowel preparations significantly increase patient satisfaction and willingness to repeat the procedure (OR 1.76; 95% CI 1.06-2.91; $P = 0.03$).[15] Similarly, a meta-analysis by Martel et al[84] revealed that more patients were willing to repeat split-dose bowel preparation (OR 1.90; 95% CI 1.05-3.46), with low-volume preparations (OR 4.95; 95% CI 2.21-11.10) preferred over high-volume split-dose preparations. Thus, lower volume regimens (e.g., $\leq$2-L compared with 4-L) are likely associated with higher compliance due to easier tolerability.[64] This is supported by another meta-analysis, which reported similar bowel cleansing efficacy between low and high-volume bowel preparations but greater tolerability for low-volume solutions, including both PEG and non-PEG solutions.[85] Overall, a personalized, multifaceted educational approach that utilizes both traditional and modern communication methods, along with a split-dose, low-volume regimen, can

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significantly enhance patient adherence to colonoscopy preparation.

COST

When choosing a bowel preparation agent, cost should be a major consideration due to the substantial financial implications of inadequate bowel preparation. It is important to note that the total cost of a colonoscopy typically includes both facility and professional fees, which is often overlooked when comparing the cost of the cheaper bowel cleansing agents. Brand-name bowel preparations are prescribed more frequently than their generic counterparts, despite a lack of evidence demonstrating the superiority of brand-name formulations.[86] For example, one study found that OSS prep resulted in fewer repeat procedures compared with PEG-ELS, although this finding was based on a single dose of 4-L of PEG-ELS and may not represent split-dose regimens.[87] Ongoing developments in bowel preparation agents aim to improve their effectiveness and patient tolerance. Some of these agents, while demonstrating similar efficacy to PEG-ELS, are more expensive due to the lack of generic alternatives.[10] Read et al highlighted a significant increase in the cost of brand-name preparations, amounting to a $13 million rise in spending from 2013 to 2015.[86]

Typically, the initial choice for bowel preparation regimens are generic options like PEG-ELS or magnesium citrate, primarily due to their affordability while maintaining comparable effectiveness to brand-name preparations. However, it is noteworthy that OSS has also emerged as an affordable and effective alternative for bowel preparation. For instance, Huynh and colleagues demonstrated that OSS was associated with lower procedural costs and reduced overall colonoscopy costs when compared with PEG-ELS, assessed on a per-patient per-year (PPPY) basis. Specifically, the cost of OSS was $6.60 PPPY, compared with PEG-ELS at $1.22 PPPY. Concerning total costs PPPY, OSS amounted to $280.34, whereas PEG-ELS was $296.36.[87]

CONCLUSION

Selecting the right bowel preparation regimen for colonoscopies is essential for effectiveness and cost management. Generic brands are typically the first-line choice due to their comparable efficacy at lower costs. Emerging alternatives are proving cost-effective and may yield better outcomes for individualized patient care. Further research is needed to comprehensively assess the cost and efficacy of generic and brand-name bowel preparations. These insights will improve CRC screening, ensure patient well-being and acceptance, and promote cost-effective health care practices. With numerous bowel preparation options available, shifting towards low-volume regimens or OSS agents is becoming common to reduce patient discomfort. This trend is expected to continue, potentially replacing 4-L of PEG-ELS (including split dosing) as the primary bowel preparation method.

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